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PSYCHOACOUSTIC SPEECH TESTS: A MODIFIED RHYME TEST

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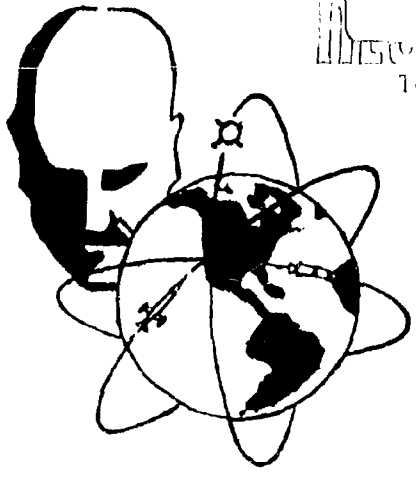

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PSYCHOACOUSTIC SPEECH TESTS:
A MODIFIED RHYME TEST

ABSTRACT

A multiple choice, easily scored speech test has been developed and evaluated. It was found that the speech intelligibility scores obtained with this test remain consistent for a given communication system when tested nearly daily for a period of one month using enlisted personnel as test listeners.

This TDR has been reviewed and is approved.

ANTHONY DEBONS
Colonel, USAF
Director, Decision Sciences Laboratory
Deputy for Engineering and Technology

SECTION 1

INTRODUCTION

There is a pressing need in some branches of the military services to routinely evaluate the ability of voice communication systems to transmit intelligible speech. Ideally this "evaluation" should be done in a manner that provides a direct quantitative measure of the ability of operational personnel to understand spoken messages over any system. The testing procedures should require but a few minutes, little or no equipment, and untrained listeners. This method or technique should, of course, be reliable and should supplement the less direct pure-tone "calibration" and other electronic test procedures typically used to check the electronic functioning of a speech system.

The most obvious methods to use are the so-called speech "articulation" or speech "intelligibility" tests. Such tests have been used for many years in the laboratory for the evaluation of the performance of speech communication systems.

Unfortunately, the literature dealing with speech intelligibility and articulation testing gives ample evidence of the tedious and time-consuming nature of these methods. Testing methods that are convenient to administer and score, and, at the same time, are short and reliable do not appear to be available. The present investigation represents an attempt to develop and evaluate an instrument that can be used routinely by relatively naive talkers and listeners, that is, operational personnel, to evaluate the condition of communication systems.

The format used is similar in general respects to that described by Fairbanks as a rhyme test.[1] It differs somewhat in its composition,

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1. G. Fairbanks, Test of phonemic differentiation: The rhyme test. J. Acoust. Soc. Am. 30, 596-600 (1958).

consisting of six alternate word lists in which no account is taken of word familiarity, nor of the relative frequency of occurrence of sounds in the language, nor of the orthographic constraints imposed on the Fairbanks' materials. In addition, the present materials use variable phonemic elements in word-final as well as word-initial position.

The major innovation in the present investigation has to do with the task required of the listener. The listener has available to him a closed set of six alternatives from which he is required to select his identification of the message. The response sets are generated automatically by the structure of the six forms of the articulation test. In actuality the listener has available a complete description of the overall message set and he is asked to select from it the word being transmitted. This technique has the advantage of eliminating the learning time required in the usual speech intelligibility tests where the listeners must be trained for a number of days before they become thoroughly familiar with all the words used in the speech tests. Since little or no learning is required it should be possible to make use of relatively naive listeners. In addition, it is believed that the test, with suitable "scramblings" or re-arrangements of the test items, can be administered over and over again to the same listeners without the scores changing as a result of the listeners finding the test "easier" with practice. This, of course, is an important problem for the repeated, periodic testing of speech systems in the field.

The materials to be described retain a high degree of phonemic balance from test form to test form, and, therefore, lend themselves to analytic appraisals of transmission in terms of speech sound elements. The identification of sound confusions in a speech link constitutes valuable diagnostic information that can lead to the identification of specific malfunction.

SECTION 2

THE TESTS AND ANSWERS SHEETS

Six lists of American English words were used as test materials, each list consisting of 50 monosyllabic words. As a rule the words are of the form consonant-vowel-consonant (CVC); some few words take the form CV or VC. The lists were constructed in such a way as to form 50 ensembles, each composed of six related words. Any given ensemble is characterized by one vowel that is the nucleus of each word; all of the words in a given ensemble either are initiated or terminated by the same consonantal phoneme or phoneme cluster.

An example of an ensemble in which each word contains the vowel /i/ and ends with the consonant /t/ is

meat, feat, heat, seat, beat, neat.

Each word in this ensemble appears in a different test list, while the ensemble itself is presented to the listener as a finite, response set.

The ensembles used in this study include 25 in which the final consonant is constant and 25 in which the initial consonant is constant. Elements that were varied in initial position in words number 20 (including the absence of a consonant, indicated by #), but six of these did not appear in all test forms. Similarly, 20 consonantal elements were used as variables in final position, but only 10 appear in all test forms. In all, 23 variable elements are used in the test material, 13 occurring in initial position in every test form, 10 occurring finally in every form, and nine occurring both initially and finally in every test form. The number of times variable elements occur is given in Table 1.

Table 1. Frequency of occurrence of variable consonantal elements. The symbol # indicates the absence of a consonant. Items marked * occur in all six test forms in word initial position; items marked + appear in all test forms in word final position.

t*+	29	r*	12
k*+	27	w*	9
s*+	26	v	6
n+	24	ŋ	5
p*+	23	#	5
b*+	20	θ	5
d*+	19	z	4
l*+	17	ʃ	3
m*+	16	tʃ	3
f*	16	ʤ	3
g*+	14	ð	2
h*	12		

The nonvarying consonantal elements used in the word lists are shown in Table 2; Table 3 shows the distribution of vowel sounds according to ensemble structure.

Table 2. Frequency of occurrence of constant nonvocalic elements in ensembles, according to position in word.

	Initial	Final		Initial	Final
p	5	2	f	1	0
b	3	0	s	5	0
t	2	3	l	1	4
d	2	2	r	1	0
k	3	2	h	1	0
g	0	1			
			st	0	2
m	1	1	nt	0	1
n	0	3	rk	0	1
ŋ	0	1			
			#	0	2

Table 3. Frequency of occurrence of vowel sounds, according to consonantal structure of ensemble.

Variable	Vowel										
	i	I	ɛ	e	æ	a	o	ʌ	ɔ	ɔɪ	U
Initial Consonant	2	6	4	3	1	3	1	2	1	1	1
Final Consonant	5	5	0	5	5	0	0	5	0	0	0

The spoken lists. Since the individual words were to be identified by the listeners as a particular item in a known response set, that is, as one of six words, the order of the items in each of the six test lists is best considered as an order of ensembles. The 50 ensembles, therefore, were arranged arbitrarily in three orders, providing three forms of each of the six test lists (see Appendix I). These 18 word lists were read by two adult male talkers with experience in the recording of materials for use in listening tasks. Between each word approximately 5 sec was provided for the listener's response. The words were spoken without instrumental monitoring, the talkers attempting to maintain a constant level of vocal effort throughout each list.

The lists were recorded on magnetic tape on a high-quality system arranged in a two-room sound-treated recording facility. The major components of the system were an Altec 21-D microphone system and an Ampex 351-2 tape recorder operating at 15 ips. The talkers were seated comfortably and the microphone was positioned 12 in from their lips. The recorder gain was adjusted so that talker levels were approximately equal.

The response forms. The listener always was provided with a response form that contained the 50 word ensembles in the proper order of the presentation. Each ensemble was enclosed in a rectangular box with its six words on two lines, as for example,

meat	feat	heat
seat	beat	neat

Listeners were instructed to draw a line through the item heard. A copy of the written instructions presented to the listeners is included in Appendix II.

In addition to varying the order of ensembles on the response form to correspond to the order of word presentation in the three lists recorded by the talkers, the arrangement of items in each response ensemble was permuted systematically so that each word appeared once in every location. (This concern with possible spatial biases was motivated by considerations relevant to eventual mechanization of tests of this type, since button-pressing activities may be biased by spatial location.) In other words, six different response sheets were available for each form of the test; only three orders of ensembles occurred on the response sheets, but similar ensemble orders differed in the arrangement of the words within ensembles. Samples of the six response sheets are included in Appendix II.

SECTION 3

EXPERIMENTAL EVALUATION OF TEST

An experiment was performed to determine the general reliability and acceptability of this new test when administered under a wide variety of voice conditions to Air Force enlisted personnel. In this experiment we wished to determine whether: (a) the different forms of the tests differed in terms of difficulty under different testing conditions; (b) the listeners required any special training in order to use the tests; (c) the scores of a group of listeners changed significantly with repeated exposure to the same test forms; and (d) there were nonfunctional or "dead wood" items present in the tests.

The word lists were presented to listeners at six ratios of signal and noise. The master recordings of the lists were played on a high-quality tape system and mixed appropriately with speech-shaped noise before presentation to the listeners under an earphone. The arrangement of the stimulus presentation equipment is shown in block diagram form in Fig. 1. All listening was done monaurally with TDH-39 (10-ohm impedance) earphones; a dummy earphone was on the opposite ear. Subjects were seated comfortably in arm-desk chairs located in a relatively quiet classroom at an Air Force Base.

The speech output of an Ampex 601 playback was constant at a level of approximately 80 db SPL, and the noise level was manipulated to provide signal-to-noise ratios of +4, 0, -4, -8, -12, and -16 db. These levels were arrived at during preliminary training sessions.

The listeners were 18 enlisted men on active duty in the U. S. Air Force. The ages of the listeners ranged from 18 to 28 years with a mean of 23.8 years. The hearing of all listeners was tested with a standard clinical audiometer. Two subjects had slight deviations of acuity from normal threshold for pure tones at 4 and 6 kcps, but not sufficient for rejection as subjects; no other abnormalities were noted.

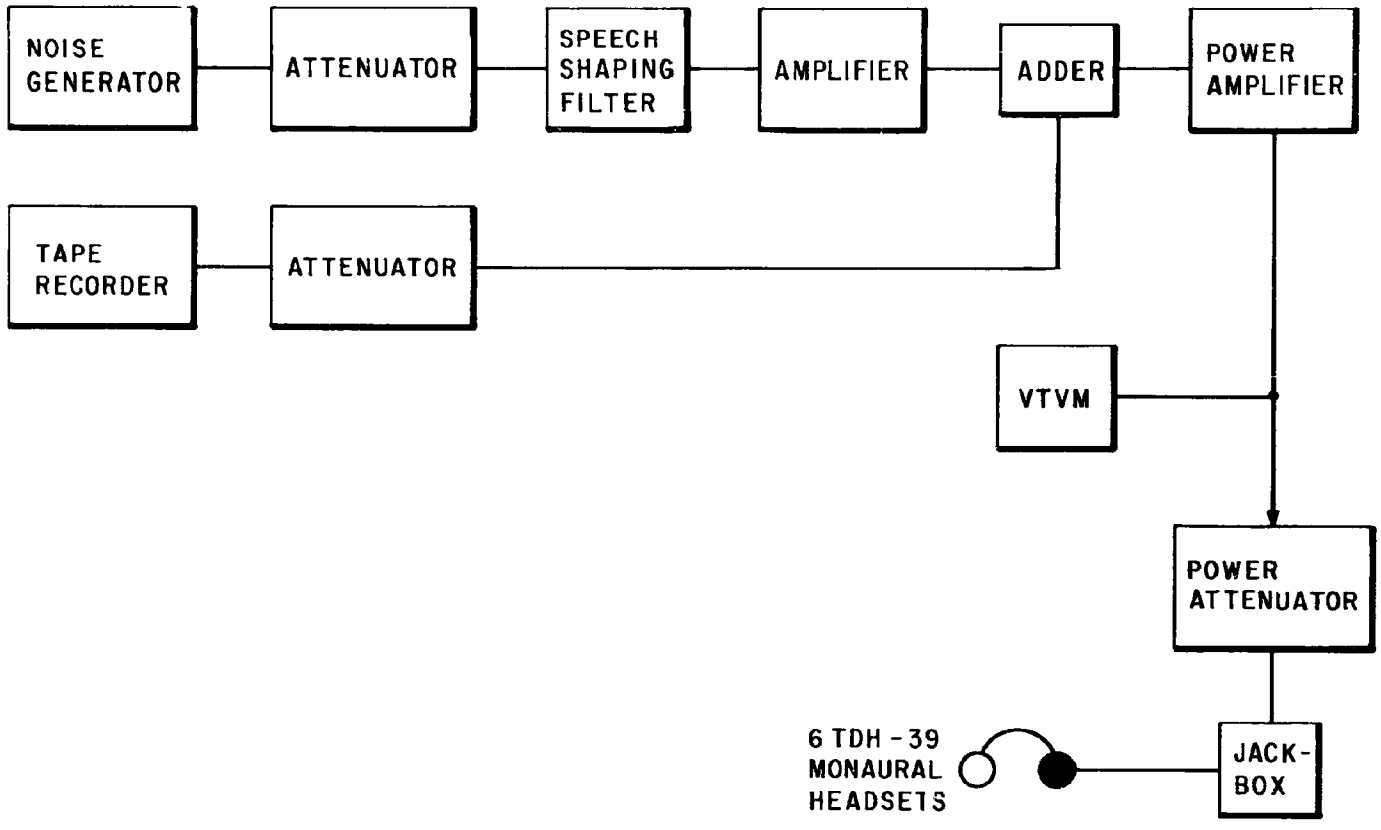

FIG. 1 BLOCK DIAGRAM OF EQUIPMENT FOR STIMULUS PRESENTATION

In order to cancel out various biasing effects on the listeners' responses, the order of presentation of the test materials was regulated by a schedule based on a quasi-symmetrical, 12 x 12 latin square. In this schedule each row of the matrix contained each of the six test lists produced by each of the two talkers; such a sequence of lists, that is, one row of the matrix, was equivalent to two listening sessions. Within each row, however, the signal-to-noise ratio at which lists were presented was varied, as was the (ensemble) order within lists and the arrangement of response ensembles, that is, response sheets, in the hands of the listeners. The arrangement was not completely counterbalanced, and the listeners did not have an opportunity to hear both talkers' versions of every list at each signal-to-noise level. All lists were presented at every level, however, and each talker was heard at every level.

In practice, the 18 listeners were divided into four groups, two groups consisting of four men and two consisting of five men. The listening schedule of each group of subjects was started on a different row of the matrix, and progressed thereafter from row to row until all of the conditions of the entire schedule had been experienced. The testing procedures were accomplished over a period of approximately 30 days. The listeners did not score their own response sheets after each test was administered, and, hence, were not aware of their successes and failures as the experiment progressed.

Results

The general results of the testing procedures are displayed in Fig. 2. Responses are averaged over 18 listeners and the percent correct is plotted versus the six presentation levels. The average responses to the various test forms, A-F, are identified for each of the two talkers versions of these materials. Solid

lines connect the level of average response to each talkers' materials at the various levels.

This presentation indicates clearly that, on the average, the listeners found the tests recorded by one talker more intelligible than those recorded by the other talker. This disparity is consistent from level to level; although at high levels of correct response the difference between the two sets of materials is reduced, the recording of the two talkers elicit responses at different levels of success even in the most favorable signal-to-noise condition.

The progression from poor response at unfavorable S/N levels to increasingly better levels of success as the S/N conditions are improved is approximately as expected. The response improvement over the linear portion of the curves, however, is about 5% for every 1 db of improvement in S/N level. This increase in successful response is at a faster rate than reported by Fairbanks with comparable materials in a different test format. The six nominal S/N levels, selected on the basis of pilot data runs, can also be seen to be inefficient; perhaps smaller separations between levels and a general shift toward larger negative ratios would have been more suitable.

The average responses to the six test forms at various levels are tabulated in Table 4, part A. The average levels of response to the six forms of the test, the column means, are seen to be highly similar, as suggested by the lack of correlation between various tests from level to level in Fig. 2. A statistical test of significance, of course, cannot reject the hypothesis of no difference between test form means.

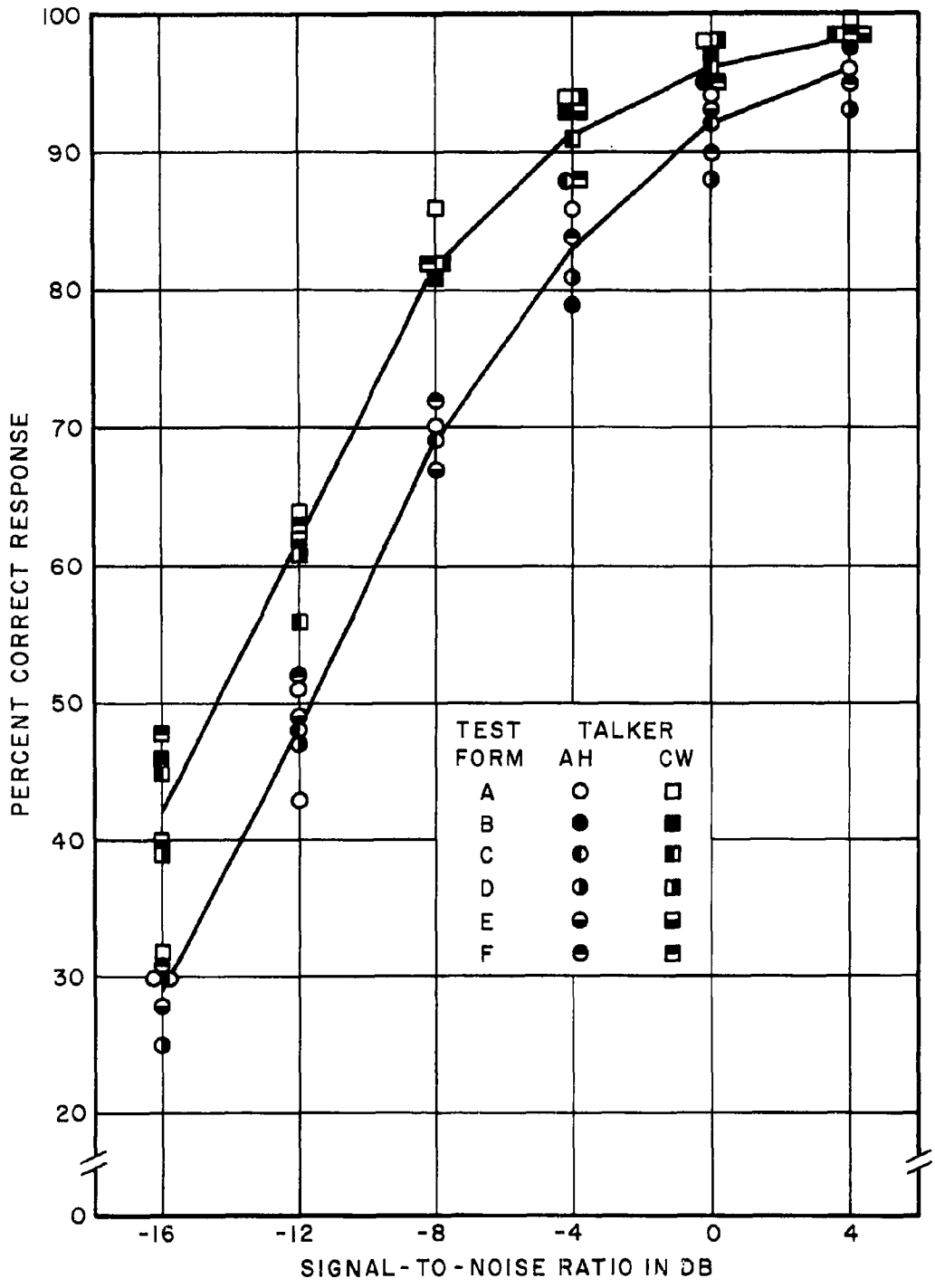

FIG. 2 CORRECT RESPONSES AVERAGED FOR 18 LISTENERS

Table 4. Average percent correct response for 18 listeners arranged according to test form and signal-to-noise level of presentation. Part A: actual data. Part B: average 'corrected' to account for talker differences.

A

S/N Levels (dB)	Test Forms						Mn	SD
	A	B	C	D	E	F		
-16	32	43	33	34	33	38	35	4.0
-12	53	51	50	57	55	60	54	3.4
-8	74	81	69	83	66	79	75	6.1
-4	90	86	90	84	93	85	88	3.1
0	96	95	94	90	93	92	93	2.2
+4	98	98	97	92	98	95	96	2.2
Mn	74	76	72	73	73	75	74	

B

-16	31	38	36	32	34	40	35	3.5
-12	54	56	52	54	56	58	55	2.1
-8	78	75	76	76	75	77	76	1.2
-4	90	86	90	88	88	86	88	1.8
0	96	96	94	93	95	93	94	1.4
+4	98	98	97	96	97	97	97	0.8

The row (that is, level) means in this table are essentially as forecast by Fig. 2, but the magnitude of the standard deviations may be surprising. These SD's reflect the variation seen in the form scores at a given level; this variation is attributable to the incomplete balance in the test administration. The entry 81% for Form B at level -8, for example, is based only on responses to talker CW, and, therefore, is an inflated estimate. The lower portion of the table, part B, is an estimation of the scores that would have resulted if complete balancing had been achieved. Missing entries have been estimated by averaging other forms. This reconstruction emphasizes the stability of responses from level to level, and would result in smaller values of SD.

A test of the row means in Table 4, part A, indicates, as expected that statistically significant differences do exist between these values. For these data, a difference of about 10% is required at the 5% level of confidence. In Fig. 3 the form-to-form variation suggested by Table 4, part B, is displayed graphically for the four most unfavorable S/N ratios. The average correct response for the 18 subjects over six S/N levels is included.

Table 5. Average percent correct responses for 18 listeners arranged according to listening groups. Data arranged over levels, test forms, and talkers.

Group	Individuals					Mn.
1	71	74	72	73	76	73
2	73	72	73	75	-	73
3	77	72	74	76	75	75
4	73	73	76	75	-	74

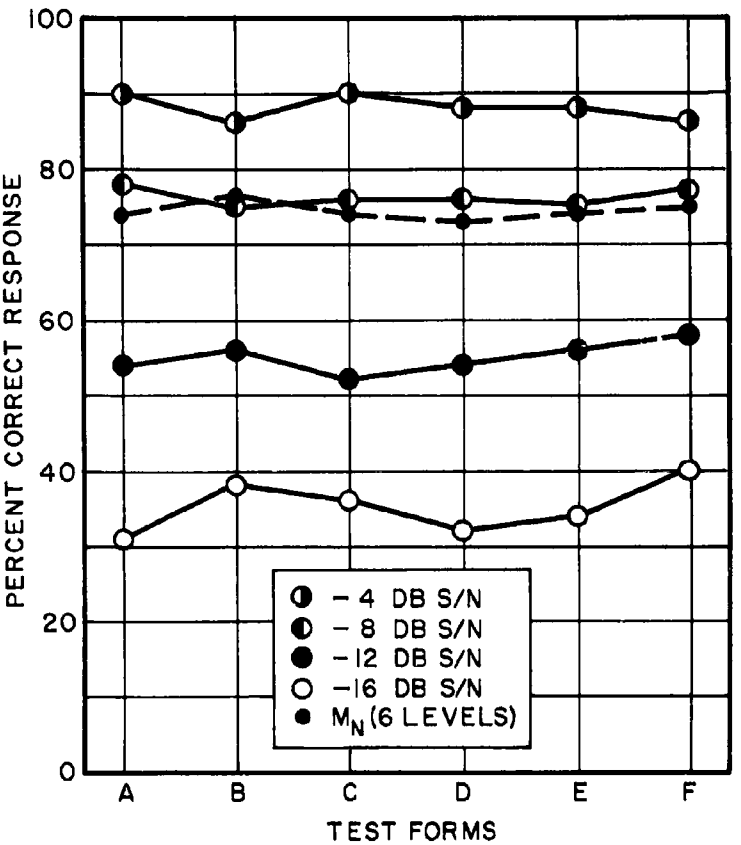

FIG. 3 AVERAGED RESPONSES SHOWING TEST FORM CHARACTERISTICS

The behavior of the listeners follows patterns commonly found in behavioral experiments. The average percent correct response for each of the 18 listeners was close to the grand average of 74%. The standard deviation of individual averages was 1.7; the range was 6, varying from 71% to 77%. The 18 listeners whose data are analyzed were rotated through the listening schedule in four groups. The group averages and individual averages are reported in Table 5.

A rapid indication of the differences, albeit small, that exist amongst the listeners is afforded by examining the mean performance level of each subject on each row of the schedule matrix. Each matrix row included two talkers versions of the six test forms, and included tests at all six S/N ratios. The Friedman[2] nonparametric test of significance was applied to the ranks of the matrix means for each listener and indicated that the differences among the listeners' averages would occur by chance with a probability less than 0.01. The test indicates essentially that substantially high correlation exists between the performance of the individuals in the listening group from row to row in the listening schedule. Rank-difference correlation coefficients for the 18 listeners calculated between individual rows of the schedule matrix and the grand average for each listener ranged for 0.40 to 0.85 (with 7 out of the 12 coefficients exceeding 0.75).

These findings suggest that a high degree of temporal stability exists in the materials. Figure 4 shows the average response of the 18 listeners at the various S/N levels on their 'nominal' first and last testing days. Repeated exposure to the materials did not change the average response levels in any appreciable way.

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2. S. Siegel, Nonparametric Statistics for the Behavioral Scientist (New York: McGraw Hill, 1956).

Some additional insight into the variability of the responses of individual listeners was sought by examining the scores of individual tests. For example, the 18 listeners heard talker AH in 12 tests administered at a S/N ratio of -8db. (The forms included in these 12 tests were A, C, E and F.) The standard deviation of the 12 scores provided by each listener was computed and these were found to range from 5.6 (4 listeners!) to 10.7%; the average of the 12 SD's was 7.8.

Table 6. Average percent correct responses arranged according to test forms and position of phonetic variable.

	A	B	C	D	E	F
Initial	78	81	79	79	78	81
Final	68	71	66	67	68	67

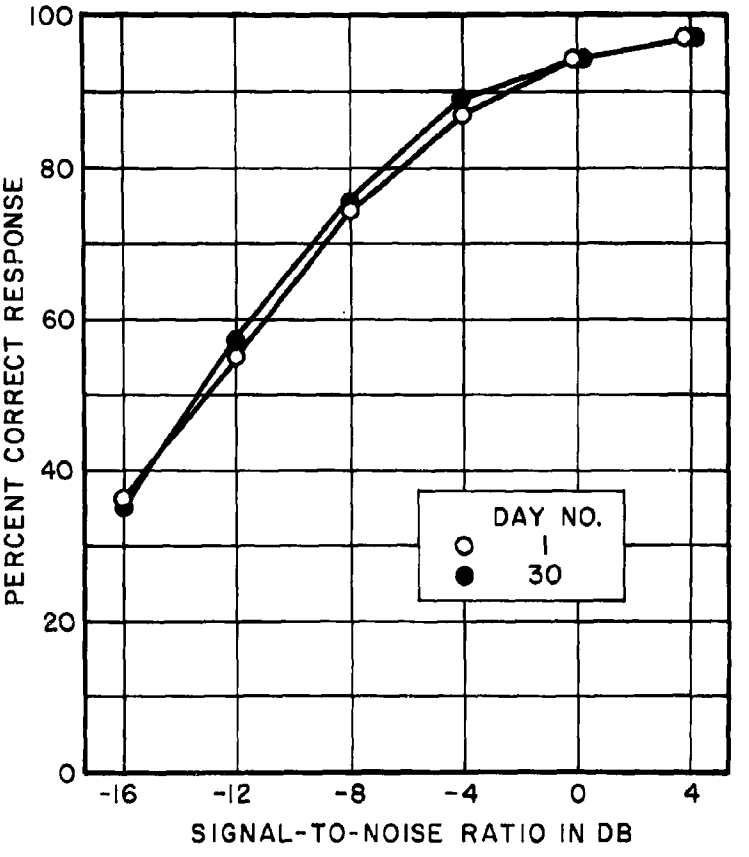

FIG. 4 AVERAGE RESPONSES SHOWING TEMPORAL STABILITY

Tests of Initial and Final Consonants

Since each of the six alternate forms consists of 25 items in which word-initial consonant sounds are under test and 25 items in which word-final sounds are under test, it may be of interest to examine these two halves separately. In general the distribution of sounds under test is similar in these two halves, the major exceptions being consonants that occur in English only in one or the other position. The sound h, for example, does not occur in word-final position in the language; similarly for the sound w. A few sounds are used in only one half of the test to provide a needed ensemble, z in final position, for example.

The average percent of correct response for the two halves of the various forms of the test is given in Table 6. The tabulated data indicate that the halves of each form behave very similarly, the variation in average correct response from form to form being very low. The data demonstrate the generally known fact that initial consonants are more recognizable than final consonants, the average correct response to the latter being 68% and to the former, 80%. The question of whether either half of the test would be sufficient for testing purposes seems worthy of investigation.

The responses of the listeners can be analyzed to reveal the degree of success with which various consonantal elements were identified. In Table 7 are tabulated the average percent of correct responses associated with various consonantal elements, as indicated. The results are shown separately for consonants in initial and final positions. These data indicate that while the superiority of initial consonants over final consonants is generally maintained, there are instances where no appreciable difference is found. They also show a tendency for the voiceless form of cognate sounds to be heard more correctly than the voiced form, as for example, p > b, f > v, t > d.

This last finding is of particular interest since it is at variance with classical descriptions of speech sound discrimination results. The data reported by Fletcher[3], for example, indicate that, on the average, the voiced forms are perceived more readily than unvoiced forms. The Fairbanks' (1) rhyme test data support this general observation (but there are some inversions in his Table VI, notably s > z and f > v).

The data on Table 7 are also at variance with the descending order of percent correct identification of sounds reported by Fairbanks (1). He found, for example, that when the general level of identification for his materials as a whole was 50%, the nasal consonants m and n were correctly identified at the highest rate while s, p and t were poorly identified. Examination of Table 7 reveals that these sounds in initial position (Fairbanks' materials were all in this position) rank inversely to the Fairbanks data. The data in Table 7, of course, are averaged over six signal-to-noise ratios but examination of the data in detail reveals that the general order is maintained from level to level. When the 14 sounds in Fairbanks' Table VI that appear in Table 7 are compared a rank-difference correlation coefficient of -0.53 results, indicating a general inversion in order. It is possible that disagreements between our results and those reported by Fairbanks and others may be at least partially due to differences in the characteristics of the masking noises used in the various experiments. In contrast to the earlier studies which used noise of equal intensity at all frequencies, the present study used a masking noise that was shaped to approximate the long-time speech spectrum envelope.

Confusion Matrices

A detailed analysis of the confusions manifested by the listeners' responses is not undertaken here. In general, it can be said that these confusions follow theoretical expectations and previous results to a marked degree.

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3. H. Fletcher, Speech and Hearing in Communication (New York: D. Van Nostrand Co. Inc., 1953).

Table 7. Average percent correct responses arranged according to phonetic elements. Initial (I) and final (F) occurrences of phonetic elements are tabulated separately. The symbol * indicates that a sound in a given position is not in all six forms of the test; the symbol ** indicates that the sound occurs in but one form of the test in the position indicated.

	I	F		I	F
p	82	56	tʃ	-	83*
t	91	79			
k	83	65	dʒ	85**	69**
b	72	57	m	67	38
d	75	64	n	66**	64
g	77	70*	ŋ	-	57*
f	86	74*	w	79	-
θ	81**	56*	r	69	68
s	98	96	l	71	74*
ʃ	61*	-			
h	70	-	#	70*	79*
v	61**	65*			
ð	66**	44**			
z	-	91			

Confusion matrices for the 50 ensembles averaged over talkers, listeners, test forms and six signal-to-noise ratios make up the body of Appendix III. These matrices reproduce the number of responses made to each word in every ensemble. The arrangement of words is arbitrary and the rows do not correspond to test forms. Since there was an imbalance in the original schedule for administering the tests the row totals are not the same, but vary between 432 and 437; the total number of responses in each matrix is 2604.

The average correct response to each word has been derived from the matrices in Appendix III and is reported as a percentage in Appendix I.

Appendix I

The test materials are presented as a list of ensembles, arranged in two parts. Ensembles are read across the rows. The first 25 ensembles are formed by variation of final (phonetic) elements, and are tabulated alphabetically by initial letter. The second 25 ensembles are formed by variation of initial elements and are ordered alphabetically by final letter.

The columns headed by letters A-F represent forms of the test. The right hand columns headed by the numbers 1-3 indicate the ensemble (and test) orders used in the three versions (scrambles) of each test form as used in the present experiment.

The number in parentheses that follows each word is the percent of correct responses averaged over 18 subjects, 6 levels and 2 talkers. The numbers in parentheses following form headings are averages of correct responses over 25 words; the numbers in parentheses following each ensemble number are averages of correct responses for each ensemble.

Section 1: Variations of Final Element

	Forms						Orders		
	A(68)	B(71)	C(66)	D(67)	E(68)	F(67)	1	2	3
1(77)	bat(70)	bad(68)	back(55)	bass(98)	ban(70)	bath(60)	43	17	36
2(56)	bean(47)	beach(83)	beat(76)	beam(14)	bead(55)	beak(59)	35	34	50
3(73)	bun(72)	bus(99)	but(63)	buff(71)	buck(56)	bug(75)	27	48	17
4(64)	came(38)	cape(55)	cane(50)	cake(72)	cave(69)	case(97)	41	21	40
5(74)	cut(80)	cub(63)	cuff(70)	cup(66)	cud(70)	cuss(98)	37	30	44
6(70)	dig(71)	dip(80)	did(62)	dim(65)	dill(67)	din(74)	4	8	22
7(61)	duck(76)	dud(68)	dung(63)	dub(26)	dug(64)	dun(68)	46	11	30
8(76)	fill(73)	fig(81)	fin(71)	fizz(94)	fib(54)	fit(82)	39	25	43
9(63)	hear(73)	heath(54)	heal(62)	heave(71)	heat(86)	heap(30)	14	29	47
10(73)	kick(62)	king(83)	kid(71)	kit(82)	kin(63)	kill(75)	18	37	13
11(67)	late(79)	lake(65)	lay(80)	lace(96)	lane(59)	lame(21)	2	4	18
12(67)	map(50)	mat(76)	math(57)	man(67)	mass(97)	mad(54)	32	40	9
13(73)	page(69)	pane(73)	pace(96)	pay(78)	pale(61)	pave(63)	10	20	35
14(71)	pass(97)	pat(83)	pack(52)	pad(69)	path(54)	pan(69)	50	3	21
15(79)	peace(87)	peas(88)	peak(63)	peal(70)	peat(81)	peach(86)	24	47	12
16(67)	pill(71)	pick(64)	pip(46)	pig(78)	pin(66)	pit(80)	8	16	31
17(68)	pun(65)	puff(70)	pup(53)	puck(54)	pus(98)	pub(69)	16	33	3
18(79)	rave(60)	rake(63)	race(96)	rate(87)	raze(89)	ray(79)	20	41	6
19(61)	sake(72)	sale(64)	save(64)	sane(58)	safe(77)	same(32)	31	42	11
20(70)	sad(64)	sass(99)	sag(63)	sack(65)	sap(55)	sat(73)	22	49	14
21(49)	seep(48)	seen(52)	seethe(44)	seed(45)	seem(26)	seek(80)	45	13	32
22(67)	sing(76)	sit(72)	sin(65)	sip(46)	sick(72)	sill(70)	29	44	15
23(64)	sud(72)	sum(43)	sub(71)	sun(72)	sup(72)	sung(54)	6	12	27
24(64)	tab(57)	tan(54)	tam(61)	tang(81)	tack(63)	tap(70)	12	24	39
25(75)	teach(81)	tear(74)	tease(92)	teal(65)	team(70)	teak(68)	48	7	25

Section 2: Variation of Initial Element

	Forms						Orders		
	A(78)	B(81)	C(79)	D(79)	E(78)	F(81)	1	2	3
1(78)	led(67)	shed(98)	red(66)	bed(74)	fed(82)	wed(78)	47	9	28
2(85)	sold(97)	told(99)	hold(60)	fold(89)	gold(78)	cold(85)	1	2	16
3(72)	dig(67)	wig(77)	big(66)	rig(54)	pig(79)	fig(90)	42	19	38
4(86)	kick(79)	lick(73)	sick(98)	pick(88)	wick(82)	tick(94)	28	46	1
5(79)	book(62)	took(97)	shook(95)	cook(82)	hook(65)	look(75)	19	39	4
6(67)	hark(63)	dark(73)	mark(60)	lark(54)	park(78)	bark(73)	38	28	46
7(82)	gale(79)	male(66)	tale(86)	bale(74)	sale(100)	pale(84)	23	45	10
8(77)	peel(81)	reel(76)	feel(85)	heel(74)	keel(81)	eel(63)	13	27	45
9(78)	will(76)	hill(61)	kill(86)	till(93)	fill(88)	bill(66)	21	43	8
10(83)	foil(80)	coil(84)	boil(76)	oil(76)	toil(83)	soil(98)	40	23	42
11(86)	fame(80)	same(99)	came(85)	name(74)	tame(90)	game(86)	30	37	41
12(73)	ten(93)	pen(86)	den(65)	hen(61)	then(66)	men(68)	36	32	48
13(88)	pin(85)	sin(98)	tin(92)	win(84)	din(79)	fin(90)	5	10	24
14(80)	sun(99)	nun(70)	gun(75)	fun(87)	bun(65)	run(82)	26	50	19
15(82)	rang(79)	fang(89)	gang(74)	bang(76)	sang(99)	hang(78)	33	38	7
16(84)	tent(92)	bent(81)	went(80)	dent(76)	rent(73)	sent(99)	25	1	26
17(83)	sip(98)	rip(75)	tip(92)	dip(81)	hip(79)	lip(72)	34	36	5
18(81)	top(76)	hop(79)	pop(79)	cop(80)	mop(73)	shop(96)	11	22	37
19(72)	meat(58)	feat(89)	heat(69)	seat(99)	beat(68)	neat(51)	17	35	2
20(82)	kit(84)	bit(74)	fit(84)	sit(98)	wit(75)	hit(77)	49	5	23
21(77)	hot(75)	got(78)	not(72)	pot(75)	lot(69)	tot(93)	7	14	29
22(72)	nest(64)	vest(61)	west(75)	test(94)	best(71)	rest(66)	44	15	34
23(78)	bust(78)	just(90)	rust(76)	must(71)	gust(73)	dust(80)	3	6	20
24(80)	raw(63)	paw(82)	law(70)	jaw(85)	thaw(81)	saw(97)	15	31	49
25(83)	way(81)	may(72)	say(98)	gay(83)	day(75)	pay(89)	9	18	33

Appendix II

The materials presented to the listeners included standard instructions and various response forms. The instructions were given in the written form shown here and were also presented orally with the listeners following along on their own copies.

The six response forms are labeled 1X, 1Y, 2X, 2Y, 3X, and 3Y. Forms with the same number have the same order of ensembles. Each order (i.e., form number) has two word arrangements within ensembles, an X and Y designation. In addition, the arrangement of words within ensembles is never the same for any two X or Y forms, that is, the spatial arrangement of words within ensembles is different for each of the six forms.

I N S T R U C T I O N S

You are going to hear some one syllable words presented with different loudness levels of noise. Each word will be presented in a carrier phrase giving its particular item number. For example:

Number one is tree.
Number two is mile.

The word presented will be one of the six words which are printed on your answer sheet for that particular item. Your task is to identify the word presented by drawing a line through the word you hear. For example:

Number three is tow.

row ~~tow~~ low
mow sow bow

Some words will be easier to hear than others. If you are not sure what the word is -- guess. Always draw a line through one of the six words for each item number.

Are there any questions?

The above instructions were presented orally, the subjects following along on their own copy of the instructions.

NAME_____ DATE_____ TEST NO._____

FORM 1X SCORE_____

1 lick pick tick wick sick kick	14 sad sass sag sat sap sack	27 sung sup sun sud sum sub	40 cave cane came cape cake case
2 seat meat beat heat neat feat	15 sip sing sick sin sill sit	28 red wed shed bed led fed	41 game tame name fame same came
3 pus pup pun puff puck pub	16 sold told hold cold gold fold	29 hot got not tot lot pot	42 oil foil toil boil soil coil
4 look hook cook book took shook	17 buck but bun bus buff bug	30 dud dub dun dug dung duck	43 fin fit tig fizz fill fib
5 tip lip rip dip sip hip	18 lake lace lame lane lay late	31 pip pit pick pig pill pin	44 cut cub cuff cuss cud cup
6 rate rave raze race ray rake	19 gun run nun fun sun bun	32 seem seethe seep seen seed seek	45 feel eel reel heel peel keel
7 bang rang sang gang hang fang	20 rust dust just must bust gust	33 day say way may gay pay	46 dark lark bark park mark hark
8 hill till bill fill kill will	21 pan path pad pass pat pack	34 rest best test nest vest west	47 heap heat heave hear heath heal
9 mat man mad mass math map	22 dim dig dill did din dip	35 pane pay pave pale pace page	48 men then hen ten pen den
10 tale pale male bale gale sale	23 wit fit kit bit sit hit	36 bat bad back bath ban bass	49 raw paw law saw thaw jaw
11 sake sale save same safe sane	24 din tin pin sin win fin	37 cop top mop pop shop hop	50 bead beat bean beach beam beak
12 peat peak peace peas peal peach	25 teal teach team tease teak tear	38 fig pig rig dig wig big	
13 king kit kill kin kid kick	26 tent bent went sent rent dent	39 tap tack tang tab tan tam	

NAME_____ DATE_____ TEST NO._____

FORM 1Y SCORE_____

1 kick lick sick tick wick pick	14 sack sad sap sag sat sass	27 sup sub sud sum sun sung	40 cake came cave cane case cape
2 neat beat seat meat feat heat	15 sit sip sill sick sin sing	28 wed fed bed led shed red	41 tame came fame same name game
3 pun puff pup pub pus puck	16 fold sold gold hold cold told	29 pot hot lot not tot got	42 toil boil foil coil oil soil
4 hook shook book took cook look	17 but bug bus buff bun buck	30 duck dud dung dun dug dub	43 fig fizz fit fib fin fill
5 lip hip dip sip rip tip	18 late lake lay lame lane lace	31 pit pin pig pill pick pip	44 cuss cud cup cut cub cuff
6 rake rate ray raze race rave	19 run bun fun sun nun gun	32 seethe seek seen seed seep seem	45 heel peel keel feel eel reel
7 fang bang hang sang gang rang	20 dust gust must bust just rust	33 say pay may gay way day	46 mark bark dark lark hark park
8 will hill kill bill fill till	21 path pack pass pat pad pan	34 best rest nest vest test rest	47 heath heave heap heat heal hear
9 map mat math mad mass man	22 dip dim din dill did dig	35 page pane pace pave pale pay	48 then den ten pen hen men
10 pale sale bale gale male tale	23 fit hit bit sit kit wit	36 bass bat ban back bath bad	49 law saw paw jaw raw thaw
11 sane sake safe save same sale	24 tin fin sin win pin din	37 hop cop shop mop pop top	50 beat beak beach beam bean bead
12 peak peach peas peal peace peat	25 tear teal teak team tease teach	38 dig wig big fig pig rig	
13 kin kid kick king kit kill	26 dent tent rent went sent bent	39 tack tam tab tan tang tap	

NAME_____ DATE_____ TEST NO._____

FORM 2X SCORE_____

1	went sent bent dent tent rent	14	not tot got pot hot lot
2	hold cold told fold sold gold	15	vest test rest best west nest
3	pat pad pan path pack pass	16	pig pill pin pip pit pick
4	lane lay late lake lace lame	17	back bath bad bass bat ban
5	kit bit fit hit wit sit	18	way may say pay day gay
6	must bust gust rust dust just	19	pig big dig wig rig fig
7	teak team teal teach tear tease	20	pale pace page pane pay pave
8	din dill dim dig dip did	21	cane case cape cake came cave
9	bed led fed red wed shed	22	shop mop cop top hop pop
10	pin sin tin fin din win	23	coil oil soil toil boil foil
11	dug dung duck dud dub dun	24	tan tang tap tack tam tab
12	sum sun sung sup sub sud	25	fit fib fizz fill fig fin
13	seep seen seethe seek seem seed	26	same name game tame came fame
27	peel reel feel eel keel heel	40	mass math map mat man mad
28	hark dark mark bark park lark	41	ray raze rate rave rake race
29	heave hear heat heal heap heath	42	save same sale sane sake safe
30	cup cut cud cuff cuss cub	43	fill kill will hill till bill
31	thaw law raw paw jaw saw	44	sill sick sip sing sit sin
32	pen hen men then den ten	45	bale gale sale tale pale male
33	puff puck pub pus pup pun	46	wick sick kick lick pick tick
34	bean beach beat beak bead beam	47	peace peas peak peach peat peal
35	heat neat feat seat meat beat	48	bun bus but bug buck buff
36	dip sip hip tip lip rip	49	sag sat sass sack sad sap
37	kill kin kit kick king kid	50	fun sun bun gun run nun
38	hang sang bang rang fang gang		
39	took cook look hook shook book		

NAME_____ DATE_____ TEST NO._____

FORM 2Y SCORE_____

1	sent rent dent tent bent went	14	tot lot pot not got not
2	told fold cold gold hold sold	15	nest vest west rest best test
3	pass pat pack pan path pad	16	pick pig pit pin pip pill
4	lay lame lake lace late lane	17	bath ban bass bat bad back
5	sit kit wit fit hit bit	18	gay way day say pay may
6	just must dust gust rust bust	19	rig jig pig big fig wig
7	team tease teach tear teal teak	20	pace pave pane pay page pale
8	dill did dig dip dim din	21	cape cake case cave cane came
9	shed bed wed fed red led	22	mop pop top hop cop shop
10	win pin din tin fin sin	23	boil soil coil oil foil toil
11	dung dun dud dub duck dug	24	tab tan tam tap tack tang
12	sud sum sub sung sup sun	25	fill fig fin fit fib fizz
13	seed seep seem seethe seek seen	26	fame same came game tame name
27	reel heel eel keel feel peel	40	man map mass math mad mat
28	bark park lark hark dark mark	41	rave rake race ray raze rate
29	hear heath heal heap heat heave	42	sale sane same safe save sake
30	cud cuff cut cub cup cuss	43	till will fill kill bill hill
31	saw thaw jaw raw paw law	44	sick sin sing sit sip sill
32	den men pen hen ten then	45	sale tale gale male bale pale
33	puck pun pus pup pub puff	46	sick tick lick pick kick wick
34	beak bead beam bean beach beat	47	peach peat peal peace peas peak
35	beat heat meat feat seat neat	48	buff bun buck but bug bus
36	hip tip sip rip dip lip	49	sass sack sat sap sag sad
37	kid kill king kit kick kin	50	nun fun run bun gun sun
38	rang fang gang hang sang bang		
39	shook look took cook book hook		

NAME_____ DATE_____ TEST NO._____

FORM 3X SCORE_____

1	gold hold sold told fold cold	14	heal heap heath heave hear heat
2	lame lane lace late lake lay	15	paw jaw saw thaw law raw
3	bust just rust dust gust must	16	pub pus puck pun puff pup
4	did din dip dim dig dill	17	meat feat heat neat beat seat
5	sin win fin din tin pin	18	kit kick kin kid kill king
6	sun sud sup sub sung sum	19	cook book hook shook look took
7	lot not hot got pot tot	20	race ray rake rate rave raze
8	pill pick pip pit pin pig	21	bill fill till will hill kill
9	may gay pay day say way	22	sap sag sad sass sack sat
10	pave pale pay page pane pace	23	gale male tale pale sale bale
11	pop shop hop cop top mop	24	peas peal peach peat peak peace
12	tang tab tack tam tap tan	25	rent went tent bent dent sent
13	keel feel peel reel heel eel	26	sun nun gun run bun fun
27	bus buff bug buck but bun	40	soil toil oil foil coil boil
28	tick wick pick kick lick sick	41	came cape cane case cave cake
29	sin sill sit sip sing sick	42	wig rig fig pig big dig
30	name fame tame came game same	43	ban back bat bad bass bath
31	safe save sake sale sane same	44	test nest best west rest vest
32	map mat math mad mass man	45	seen seed seek seem seethe seep
33	gang hang fang bang rang sang	46	dun dug dub duck dud dung
34	sip rip tip lip hip dip	47	led shed red wed fed bed
35	beach beam beak bead beat bean	48	tease teak tear teal teach team
36	hen ten then den men pen	49	bit sit hit wit fit kit
37	cuff cuss cub cup cut cud	50	pad pass path pack pan pat
38	park mark hark dark lark bark		
39	fizz fill fib fin fit fig		

NAME_____ DATE_____ TEST NO._____

FORM 3Y SCORE_____

1	cold gold fold sold told hold	14	heat heal hear heath heave heap
2	lace late lane lay lame lake	15	jaw raw thaw law saw paw
3	gust rust bust just must dust	16	pup pub puff puck pun pus
4	dig dip did din dill dim	17	feat seat neat beat heat meat
5	fin din win pin sin tin	18	kick king kid kill kin kit
6	sub sung sum sun sud sup	19	book took shook look hook cook
7	got pot tot lot not hot	20	raze race rave rake rate ray
8	pin pip pill pick pig pit	21	kill bill hill till will fill
9	pay day gay way may say	22	sat sap sack sad sass sag
10	pay page pale pace pave pane	23	male bale pale sale tale gale
11	top hop pop shop mop cop	24	peal peace peat peak peach peas
12	tam tap tan tang tab tack	25	bent dent sent rent went tent
13	eel keel heel peel reel feel	26	bun gun sun nun fun run
27	bug buck buff bun bus but	40	foil coil boil soil toil oil
28	pick kick wick sick tick lick	41	case cave cake came cape cane
29	sing sit sin sill sick sip	42	big fig wig rig dig pig
30	came game same name fame tame	43	bad bass bath ban back bat
31	sake sale save same safe sane	44	west rest vest test nest best
32	math mad mat man map mass	45	seek seem seed seep seen seethe
33	sang gang rang fang bang hang	46	dub duck dug dung dun dud
34	rip dip lip hip tip sip	47	fed red led shed bed wed
35	beam bean bead beat beak beach	48	teach tear tease teak team teal
36	ten pen den men then hen	49	hit wit sit kit bit fit
37	cub cup cuss cud cuff cut	50	pack pan pat pad pass path
38	lark hark park mark bark dark		
39	fib fin fill fig fizz fit		

Appendix III

The word ensembles are arranged in matrix form and responses are tabulated for each stimulus, providing a display of confusions as well as correct responses. The stimulus words identify the rows at the left side of the matrix and the response words (provided by the subject's response forms) are the column headings in the matrix.

The entries in each matrix represent number of responses. Row totals are not equal but vary systematically between 432 and 437; matrix totals are 2604 in all cases.

The data are pooled over talkers, listeners, and levels; (each word, of course, is drawn from a different form of the test, but the test forms are not derivable from these matrices in terms of row placement). The same number of tests were presented at each level and the contribution of talkers to the various levels is approximately equal. Each form is represented equally in the data.

The ensemble numbers refer to the materials of Appendix I.

No. F1	bat	bad	back	bath	ban	bass
bat	305	15	49	40	17	11
bad	38	295	18	45	39	0
back	112	21	236	31	20	13
bath	94	31	31	259	8	11
ban	23	52	12	28	302	16
bass	1	1	2	4	1	423

No. F2	bead	beat	bean	beach	beam	beak
bead	236	45	95	11	15	31
beat	14	329	24	24	8	34
bean	108	43	206	12	47	21
beach	10	32	14	360	7	12
beam	80	19	245	14	59	15
beak	15	120	26	6	11	256

No. F3	buck	but	bun	bus	buff	bug
buck	243	58	17	2	94	19
but	71	273	21	6	36	26
bun	24	38	316	12	22	25
bus	2	0	1	431	1	0
buff	48	41	16	6	307	14
bug	22	25	34	4	22	327

No. F4	cave	cane	came	cape	cake	case
cave	298	27	28	31	39	10
cane	32	216	102	33	39	11
came	34	170	167	30	26	10
cape	21	13	15	238	145	3
cake	16	6	4	86	312	8
case	2	2	1	4	3	422

No. F5	cut	cub	cuff	cuss	cud	cup
cut	350	9	25	10	19	24
cub	40	276	44	6	36	33
cuff	31	9	301	11	6	74
cuss	3	0	2	422	4	2
cud	46	34	31	4	303	15
cup	47	30	50	11	11	283

No. F6	dim	dig	dill	did	din	dip
dim	279	21	17	21	80	14
dig	22	310	17	33	43	12
dill	25	27	291	47	25	18
did	21	61	24	268	51	8
din	39	20	18	24	320	13
dip	21	18	10	19	20	347

No. F7	dud	dub	dun	dug	dung	duck
dud	295	9	23	70	19	19
dub	39	111	29	197	36	21
dun	24	9	297	24	61	19
dug	46	24	31	275	37	19
dung	16	14	77	34	272	20
duck	16	19	17	29	25	331

No. F8	fin	fit	fig	fizz	fill	fib
fin	307	40	35	18	14	19
fit	15	355	20	13	11	20
fig	26	23	350	10	11	15
fizz	6	5	12	404	1	4
fill	22	37	18	9	319	32
fib	56	68	31	18	26	234

No. F9	heap	heat	heave	hear	heath	heal
heap	132	200	14	11	65	12
heat	16	374	4	8	21	10
heave	12	36	306	13	43	24
hear	19	40	9	319	20	30
heath	36	120	18	14	236	11
heal	27	50	28	32	27	269

No. F10	king	kit	kill	kin	kid	kick
king	359	9	9	29	25	4
kit	8	355	17	12	13	27
kill	16	32	324	20	29	13
kin	63	32	8	273	35	22
kid	35	26	18	21	308	25
kick	38	82	15	14	17	271

No. F11	lake	lace	lame	lane	lay	late
lake	284	3	4	3	18	123
lace	7	414	0	1	4	6
lame	15	6	91	242	41	39
lane	16	8	69	256	52	32
lay	25	1	6	26	346	29
late	30	17	7	16	21	346

No. F12	mat	man	mad	mass	math	map
mat	332	25	15	7	33	23
man	36	289	59	16	21	11
mad	40	103	235	4	38	13
mass	5	2	1	422	1	2
math	90	23	22	35	245	18
map	128	33	20	14	25	217

No. F13	pane	pay	pave	pale	pace	page
pane	316	51	23	16	8	21
pay	33	336	24	21	4	14
pave	17	101	272	18	9	17
pale	12	99	30	263	12	17
pace	2	5	3	4	415	4
page	22	51	40	12	11	301

No. F14	pan	path	pad	pass	pat	pack
pan	299	27	44	4	44	16
path	8	235	13	60	96	21
pad	25	51	298	11	33	14
pass	6	1	4	422	2	2
pat	3	20	13	2	360	37
pack	15	34	21	11	128	224

No. F15	peat	peak	peace	peas	peal	peach
peat	351	42	5	9	9	17
peak	103	272	9	15	24	10
peace	35	5	380	8	3	6
peas	16	5	15	381	5	13
peal	59	45	9	9	304	6
peach	22	16	7	8	7	374

No. F16	pip	pit	pick	pig	pill	pin
pip	200	105	48	31	32	17
pit	10	348	32	22	11	11
pick	23	73	277	36	12	14
pig	25	22	18	336	7	24
pill	17	54	23	23	308	12
pin	7	52	36	41	10	287

No. F17	pus	pup	pun	puff	puck	pub
pus	423	0	1	1	2	6
pup	6	231	11	97	56	32
pun	6	29	285	33	44	40
puff	6	47	12	303	44	22
puck	7	51	17	100	234	23
pub	3	23	26	60	21	301

No. F18	rate	rave	raze	race	ray	rake
rate	377	11	6	6	15	17
rave	40	264	24	8	82	19
raze	16	3	387	13	6	8
race	3	1	7	415	3	4
ray	37	26	10	6	343	12
rake	107	15	11	3	26	273

No. F19	sake	sale	save	same	safe	sane
sake	314	10	21	5	73	14
sale	25	279	50	13	51	17
save	34	11	275	29	65	19
same	11	14	25	139	27	218
safe	68	4	12	9	334	6
sane	22	8	33	97	23	249

No. F20	sad	sass	sag	sat	sap	sack
sad	281	4	53	50	20	29
sass	2	430	0	2	0	1
sag	86	6	272	29	9	32
sat	13	13	6	317	25	60
sap	23	8	14	92	237	59
sack	13	6	19	75	37	282

No. F21	seem	seethe	seep	seen	seed	seek
seem	114	38	14	175	40	52
seethe	21	189	23	52	92	56
seep	7	34	210	13	20	153
seen	52	38	7	225	64	49
seed	31	91	11	80	194	25
seek	3	35	26	13	12	345

No. F22	sip	sing	sick	sin	sill	sit
sip	199	15	40	15	13	151
sing	10	333	41	25	2	26
sick	21	23	310	10	4	64
sin	25	47	37	280	11	33
sill	16	20	42	17	304	35
sit	16	9	79	11	6	314

No. F23	sung	sup	sun	sud	sum	sub
sung	232	15	106	17	49	15
sup	27	313	15	15	18	45
sun	41	20	312	17	23	19
sud	12	31	27	316	11	40
sum	131	19	60	11	187	27
sub	26	30	16	38	16	307

No. F24	tap	tack	tang	tab	tan	tam
tap	305	74	12	15	16	12
tack	79	272	27	15	14	26
tang	5	11	350	9	34	23
tab	34	36	37	250	32	48
tan	12	9	70	13	234	97
tam	16	18	38	19	80	262

No. F25	teal	teach	team	tease	teak	tear
teal	281	9	46	7	63	26
teach	5	354	17	7	43	11
team	33	15	303	24	50	8
tease	3	12	6	399	11	2
teak	14	10	25	80	293	12
tear	44	3	24	6	48	320

No. I1	red	wed	shed	bed	led	fed
red	286	65	11	26	21	24
wed	47	339	6	12	19	11
shed	1	1	428	0	3	2
bed	33	44	8	320	14	13
led	41	56	9	26	294	11
fed	28	25	5	10	9	356

No. I2	sold	told	hold	cold	gold	fold
sold	425	3	0	3	3	3
told	0	429	3	1	1	1
hold	3	14	258	101	45	12
cold	3	11	20	369	16	15
gold	11	12	19	30	339	22
fold	7	12	9	15	3	386

No. I3	fig	pig	rig	dig	wig	big
fig	391	9	3	4	13	14
pig	21	342	10	8	22	30
rig	15	20	233	4	133	27
dig	24	28	6	291	37	51
wig	8	13	27	4	333	50
big	13	40	24	15	57	284

No. I4	lick	pick	tick	wick	sick	kick
lick	319	12	16	61	10	17
pick	12	382	3	19	7	9
tick	2	7	406	4	7	8
wick	15	40	10	355	4	9
sick	2	2	1	0	426	2
kick	15	23	17	20	17	345

No. I5	look	hook	cook	book	took	shook
look	326	30	13	38	17	10
hook	44	283	42	28	27	9
cook	21	19	352	15	19	6
book	89	30	19	270	14	15
took	5	2	6	0	420	2
shook	5	6	4	5	4	409

No. I6	dark	lark	bark	park	mark	hark
dark	317	44	34	9	17	14
lark	18	231	72	26	55	30
bark	10	29	318	26	41	10
park	5	11	32	338	23	24
mark	20	27	64	40	259	23
hark	3	15	23	89	32	275

No. I7	tale	pale	male	bale	gale	sale
tale	371	20	7	10	16	9
pale	11	365	13	12	25	8
male	11	23	289	73	27	12
bale	6	23	49	321	24	9
gale	14	17	20	28	345	13
sale	0	0	0	2	0	431

No. I8	feel	eel	reel	heel	peel	keel
feel	366	5	14	16	14	18
eel	24	273	22	73	22	20
reel	23	31	330	20	19	12
heel	18	48	10	321	21	14
peel	19	20	16	14	354	14
keel	19	10	5	33	15	351

No. I9	hill	till	bill	fill	kill	will
hill	265	18	30	50	43	29
till	3	401	12	2	11	3
bill	16	11	288	19	22	78
fill	8	10	6	379	17	13
kill	18	11	10	15	371	8
will	24	20	22	17	20	334

No. I10	oil	foil	toil	boil	soil	coil
oil	328	24	14	33	6	27
foil	12	350	18	14	5	38
toil	10	10	360	10	4	39
boil	41	25	14	329	6	18
soil	1	3	1	1	426	2
coil	19	25	14	7	3	367

No. I11	game	tame	name	fame	same	came
game	372	3	26	2	11	20
tame	14	390	4	6	10	9
name	33	12	318	28	10	31
fame	12	9	18	350	9	39
same	1	1	1	1	431	0
came	23	12	14	10	6	368

No. I12	men	then	hen	ten	pen	den
men	297	56	19	12	39	11
then	74	284	13	14	27	21
hen	41	18	262	21	77	13
ten	6	7	5	406	6	7
pen	26	11	10	4	376	8
den	34	78	9	17	15	280

No. I13	din	tin	pin	sin	win	fin
din	344	16	19	8	37	9
tin	9	396	3	11	8	6
pin	10	12	373	15	8	19
sin	0	2	1	425	1	6
win	14	7	20	13	363	15
fin	7	12	7	5	13	390

No. I14	gun	run	nun	fun	sun	bun
gun	322	32	28	16	11	24
run	17	356	27	14	11	10
nun	60	36	303	11	3	21
fun	27	11	6	380	4	4
sun	0	2	2	0	432	1
bun	31	75	17	18	11	281

No. I15	bang	rang	sang	gang	hang	fang
bang	326	41	3	21	19	22
rang	28	343	10	18	20	18
sang	1	1	427	1	1	2
gang	25	39	6	319	26	18
hang	22	9	7	19	338	39
fang	14	18	3	3	8	389

No. I16	tent	bent	went	sent	rent	dent
tent	404	6	7	5	7	8
bent	6	351	32	3	31	12
went	15	18	348	12	34	6
sent	1	0	1	431	0	1
rent	7	20	63	16	316	11
dent	10	35	26	8	24	329

No. I17	tip	lip	rip	dip	sip	hip
tip	399	1	8	14	6	5
lip	12	314	38	22	9	39
rip	9	44	324	23	13	22
dip	6	24	23	350	7	22
sip	0	3	3	2	427	2
hip	24	28	19	15	6	341

No. I18	cop	top	mop	pop	shop	hop
cop	344	12	7	12	4	53
top	46	330	13	12	5	31
mop	24	7	318	21	7	56
pop	21	9	26	343	6	28
shop	7	0	2	0	418	7
hop	34	12	17	28	1	343

No. I19	seat	meat	beat	heat	neat	feat
seat	427	0	1	2	1	1
meat	6	252	81	37	41	20
beat	4	62	295	27	22	23
heat	8	31	27	298	28	41
neat	5	93	48	47	221	20
feat	4	9	12	24	1	385

No. I20	wit	fit	kit	bit	sit	hit
wit	326	33	15	30	11	18
fit	16	364	22	13	4	14
kit	7	26	365	8	4	27
bit	60	13	10	322	4	26
sit	3	4	2	0	421	2
hit	16	40	18	21	4	335

No. I21	hot	got	not	tot	lot	pot
hot	329	25	27	12	11	33
got	15	338	56	11	12	3
not	29	57	312	13	8	14
tot	9	11	6	403	1	4
lot	47	32	32	5	299	18
pot	59	17	11	11	11	323

No. I22	rest	best	test	nest	vest	west
rest	287	25	12	18	26	66
best	25	307	9	10	44	38
test	3	4	405	6	6	8
nest	23	58	22	278	28	28
vest	29	63	11	30	267	35
west	47	15	15	14	18	324

No. I23	rust	dust	just	must	bust	gust
rust	331	9	12	29	24	28
dust	15	346	8	15	16	34
just	4	12	390	9	6	14
must	25	15	9	308	53	22
bust	18	12	11	41	341	14
gust	20	53	10	14	19	317

No. I24	raw	paw	law	saw	thaw	jaw
raw	276	26	70	21	31	13
paw	17	356	27	1	27	7
law	53	43	301	6	19	11
saw	3	1	2	422	3	3
thaw	8	49	14	5	351	6
jaw	12	9	21	4	20	366

No. I25	day	say	way	may	gay	pay
day	326	6	13	22	47	19
say	1	424	2	0	3	3
way	21	5	352	15	15	29
may	21	3	40	314	19	38
gay	24	2	13	13	357	21
pay	7	7	13	12	7	388

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A MULTIPLE CHOICE, EASILY SCORED SPEECH TEST HAS BEEN DEVELOPED AND EVALUATED. IT WAS FOUND THAT THE SPEECH INTELLIGIBILITY SCORES OBTAINED WITH THIS TEST REMAIN CONSISTENT FOR A GIVEN COMMUNICATION SYSTEM WHEN TESTED NEARLY DAILY FOR A PERIOD OF ONE MONTH USING ENLISTED PERSONNEL AS TEST LISTENERS.

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3. SPEECH TRANSMISSION
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5. HUMAN ENGINEERING
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III BOLT BERANEK AND NEWMAN INC., CAMBRIDGE, MASS
IV HOUSE, A.S., WILLIAMS, C., HECKER, M.H.L., KRYTER, K.D.
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